UNITED STATES DISTRICT COURT

WESTERN DISTRICT OF WASHINGTON

AT SEATTLE

HENRY BARABIN and GERALDINE BARABIN, Plaintiffs, v. ALBANY INTERNATIONAL CORP., et al., Defendants.	No. C07-1454 RSL DECLARATION OF CAMERON O. CARTER IN SUPPORT OF PLAINTIFFS' RESPONSE TO DEFENDANTS ASTENJOHNSON, INC.'S AND SCAPA DRYER FABRICS, INC.'S MOTIONS IN LIMINE TO EXCLUDE CERTAIN TESTIMONY OF JAMES MILLETTE

I, Cameron O. Carter, declare and state as follows:

1. I make the following declaration based on my own personal knowledge, and if called to testify, could testify competently thereto.

2. I am a lawyer with the firm of Brayton Purcell, representing the plaintiffs Henry and Geraldine Barabin.

3. Attached hereto as Exhibit 1 is a true and correct copy of the curriculum vitae of James R. Millette, Ph.D.

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4. Attached hereto as Exhibit 2 is a true and correct copy of the journal article titled "Microscopical Studies of the Asbestos Fiber Releasability of Dryer Felt Textiles", by James R. Millette, published in Microscope.

I certify (declare) under penalty of perjury under the laws of the States of Washington and Oregon that the foregoing is true and correct to the best of my knowledge.

DATED this 24th day of August, 2009 at Portland, OR.

/s/ Cameron O. Carter

Cameron O. Carter

J:\WA\106995\USDC (Federal)\TRIAL\RSP MILS ASTJOH SCAPAD Millette-DECL COC.wpd

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EXHIBIT 1

MVA Scientific Consultants

JAMES R. MILLETTE, Ph.D.

Summary of Credentials

EDUCATION:

B.S., Physics, University of Dayton, Dayton, Ohio, 1973
M.En., Miami University, Oxford, Ohio, 1975
Ph.D., University of Cincinnati, Ohio, 1983

WORK EXPERIENCE:

- Involved in environmental/toxicology/particle and materials studies since 1972 primarily using electron microscopy techniques.
- Present position: Executive Director, MVA Scientific Consultants, Duluth, Georgia.
- Previous work included 11 years as a research scientist at the U.S. Environmental Protection Agency Research Center in Cincinnati, Ohio and 5 years at McCrone Environmental Services performing and supervising analysis of particulates and product constituent analysis by microscopic techniques.

PUBLICATIONS:

Over 60 publications have appeared in a number of journals including Scanning Electron Microscopy, Journal of the American Water Works Association, Environmental Health Perspectives, Archives of Environmental Contamination and Toxicology, the Science of the Total Environment, Journal of Analytical Toxicology, Electron Microscopy, and The Microscope.

PRESENTATIONS:

Reports of scientific work have been presented at numerous national and international meetings, including conferences of the Environmental Information Association, American Industrial Hygiene Association, American Water Works Association, Electron Microscopy Society, and several Symposia of the Georgia Tech Research Institute.

OTHER:

- Served as chairman or co-chairman of technical sessions at national meetings such as that of the Electron Microscope Society of America.
- Chairman, Electron Microscope Facility at the USEPA Research Center, 1980-1985.
- Member of American Society of Testing and Materials. Vice-Chair for ASTM Committee D22.07 Asbestos. Member ASTM Committee D24 Carbon Black.
- Testified as an expert witness on asbestos for the State of Connecticut Department of Health.
- Adjunct Professor, Department of Zoology, Miami University, Oxford, Ohio, 1984-1985.
- President, Electron Microscope Society of the Ohio River Valley, 1984-1985.
- President, Georgia Microscopical Society, 1994-1996.
- Testified as an Expert Witness on matters relating to microscopical analyses in court.
- Co-Course Director, "Settled Dust Analysis," Georgia Tech Research Institute, 1991-1992.
- Lecturer for ASTM Technical & Professional Training Course.
- Full Member of the American Academy of Forensic Scientists.

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JAMES R. MILLETTE, Ph.D.

A. Education Background

B.S., Physics, University of Dayton, Dayton, Ohio, 1973
M.En., Environmental Science, Miami University, Oxford, Ohio, 1975
Ph.D., Environmental Science, School of Engineering, University of Cincinnati, Cincinnati, Ohio, 1983

B. Work Experience

Executive Director, MVA Scientific Consultants, Duluth, GA. June 1990 – Present.

Vice President and General Manager, McCrone Environmental Services, Inc., Norcross, GA. December 1987 - June 1990.

Manager, Laboratory Operations and Electron Optics Group, McCrone Environmental Services, Inc., Norcross, GA. July 1985 - December 1987.

Physical Scientist, Health Effects Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. July 1974 - July 1985.

Graduate Teaching Assistant, Physics Department, Miami University, Oxford, Ohio. 1973 – 1974.

Student Researcher, NSF-SOS (Student Originated Studies) Grant, Hiram College, Hiram, Ohio, entitled "Pollution Studies of Cuyahoga, Chagrin, and Grand Rivers Using Non-Dispersive X-Ray Fluorescence Spectroscopy", Summer 1973.

Student Research Assistant, University of Dayton, Dayton, Ohio. U.S. Department of Interior Contract "Determination of Trace Metal Pollutants in Water Resources and Stream Sediments by X-Ray Fluorescence", 1972-1973, including summer 1972.

Student Teaching Assistant, Physics Department, University of Dayton, Dayton, Ohio, 1971.

C. Publications

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Ghazi, A. M. and J.R. Millette, "Lead" Chapter 4. In: Environmental Forensics. R.D. Morrison and B.L. Murphy, Eds., Elsevier, New York, NY. pp 55-80, 2006

Millette, J.R., R. Few, W. Hill, and M. Ritorto. Sizing Nano-Range Primary Particles in Aciniform Carbon Aggregates Using ImageJ. *Microscope* 54(2):51-59. 2006

Millette, J.R. and R.S. Brown. Environmental Forensic Microscopy. Chapter 13 In: Introduction to Environmental Forensics, 2nd Ed., B. L. Murphy and R. D. Morrison, Eds., Academic Press, Elsevier, Amsterdam. pp:611-635. 2007

Millette, J.R. W. Turner, W.B. Hill, P. Few, and J.P. Kyle. Microscopic Investigation of Outdoor "Sooty" Surface Problems. *Environmental Forensics*, 8:37-51, 2007.

D. Awards

Elected to Sigma Pi Sigma, Physics Honorary, 1972
Elected to Society of Sigma Xi, Research Society, 1975
Outstanding Performance Rating Civil Service, 1978, 1982,1983
Publication nominated by Laboratory Director for USEPA-ORD's Scientific and Technological Achievement Award, 1979,1980,1981
American Water Works Association Distribution Division Award for best published paper 1980
Publication Award National Asbestos Council Journal 1991-1992
STAR Publication Award, Risk Reduction Engineering Laboratory, USEPA, 1994
Award of Excellence, The Environmental Information Association, Georgia Chapter, 1995
Award of Appreciation from Committee D-22 on Sampling and Analysis of Atmospheres for outstanding service to Subcommittee D22.07. October 2000

E. Technical Presentations

"Efficiency Calibration of an Energy Dispersive X-Ray Fluorescence System for Trace Metal Analysis", presented at the spring meeting of the Ohio Section of the American Physical Society, Wittenberg University, April 7, 1973. Abstract published in the Bulletin of the American Physical Society, 18:888, 1973.

"Analysis of Asbestos Fibers in Water by Electron Microscopy", co-authors J. E. Poth and E. F. McFarren, presented at the spring meeting of the Ohio Section of the American Physical Society, Kent State University, May 10, 1975. Abstract published in the Bulletin of the American Physical Society, 20:890, 1975.

"EDS of Waterborne Asbestos Fibers in TEM, SEM, AND STEM", co-author E. F. McFarren, presented at the Scanning Electron Microscopy Symposium Workshop on Technique for Particulate Matter Studies, IIT Research Institute, Toronto, Canada, April 1976.

"Monitoring Drinking Water for Asbestos by Electron Microscopy", presented at the Symposium on Electron Microscopy of Micro-Fibers, U. S. Food and Drug Administration. Pennsylvania State University, August 25, 1976.

"Effects of Water on Asbestos-Cement Materials in Drinking Water Supplies", presented at the Scanning Electron Microscopy Symposium, SEM Inc., Chicago, IL, April 1979.

"Concentration and Size of Asbestos in Water Supplies", at the Asbestos Workshop, NIEHS, DHEW, Washington, D.C., June 7-8, 1979.

"Occurrence and Health Effects of Eroded Asbestos Fibers", at the Seminar for Corrosion Control in Water Distribution Systems, USEPA, Cincinnati, OH, May 20-22, 1980.

"Fate of Ingested Particles", presented at the Workshop on the Substitutes for Asbestos, Consumer Product Safety Commission, Washington, D.C., July 14-16, 1980.

"The Need to Control Asbestos Fibers in Potable Water Supply Systems", presented at the International Water Supply Conference, Noordivijkerhout, The Netherlands, August 30-September 1, 1980.

"Particulates in Water Supplies", presented at the Clay and Clay Minerals Society Conference, Waco, TX, October 8-9, 1980.

"Some Investigations of X-Ray Microanalysis for Biological Tissue", at the Electron Microscopy Society Meeting, Louisville, KY, February 6, 1982.

"X-Ray Microanalysis of Mitochondrial Calcium Levels in Frozen Liver Tissue from Rats Exposed to Carbon Tetrachloride", poster presented at the 23rd Society of Toxicology Conference, March 12-16, 1984.

"Evaluating the Conditions of Asbestos-Cement Pipe", paper number 152 presented at Corrosion 84, an International Corrosion Forum sponsored by the National Association of Corrosion Engineers, New Orleans, LA, April 1984.

"Measurement of Calcium Level Changes in Tissue in Response to Injury by Environmental Agents", at the Fed. of Amer. Soc. for Exp. Biology Meeting, St. Louis, MO, April 1984.

"X-Ray Analysis of Freeze-Dried Sections" invited lecture at Cryo-Techniques in Electron Microscopy Symposium and Workshop, University of Iowa, Iowa City, IA, April 8-10, 1985.

"Subcellular Ions by X-ray Microanalysis for Evidence of Hepatotoxicity", Electron Microscopy Society of America and Microbeam Analysis Society Joint Annual Meeting, Louisville, KY, August 5-9, 1985.

"Use of TEM Analysis for Ambient and Clearance Sampling", University of Kentucky Symposium on Managing Asbestos in Buildings, Lexington, KY, October 23-25, 1985.

"Laboratory Analysis", Asbestos Abatement in the Federal Government 1985 Annual Symposium, Kansas City, MO, November 19-21, 1985.

"X-ray Microanalysis of Animal Cells", Miami University Zoology Department, Oxford, OH, November 29, 1985.

"Analyzing for Asbestos in Environmental Samples", Department of Geology, Emory University, Atlanta, GA, February 6, 1986.

"Transmission Electron Microscopy", National Asbestos Council, Baltimore, MD, February 20, 1986.

"Laboratory Analysis", Western States Asbestos Abatement Conference and Exposition, Los Angeles, CA, March 7, 1986.

"Electron Microscopy, Interpretation of Results", Asbestos Abatement Project Monitoring Course, Georgia Tech Research Institute, Atlanta, GA, March 26, 1986.

"Asbestos Fibers in Water", Symposium on Innovative Techniques and Recent Developments in the Asbestos Abatement Industry, Georgia Tech Research Institute, Atlanta, GA, March 28, 1986.

"Diagnostic Electron Microscopy in Environmental Sciences", Minnesota Electron Microscope Society Spring Symposium, St. Paul, MN, May 16, 1986.

"An Overview of Asbestos Analytical Methods", American Industrial Hygiene Conference, Dallas, TX, May 23, 1986.

"Experiences with Direct and Indirect Sample Preparation for TEM Analysis of Asbestos", 1986 ASTM Johnson Conference on Measurement Challenges of the 80's: Indoor Air, Acid Rain and Asbestos, Johnson, VT, July 13-14, 1986.

"Analysis of Asbestos in Environmental Samples by TEM" presented at the INTER/MICRO-86, International Microscopy Society, Chicago, IL, July 21-24, 1986.

"Comparison of Sodium Hypochlorite Digestion and Low-Temperature Ashing Preparation Techniques for Lung Tissue Analysis by TEM" co-authored and presented at the Electron Microscope Society of America/Microbeam Analysis Society Annual Meeting; Albuquerque, NM, August 11-15, 1986.

"Electron Microscopy Sampling, Analysis, and Interpretation" and "Field Applications of the EPA Guidelines for Post Abatement Air Monitoring" presented at the National Asbestos Council Meeting, New Orleans, LA, September 22-25, 1986.

"Laboratory Analysis, Bulk and Air Monitoring" presented at the Asbestos Abatement in the Federal Government, Kansas City, MO, November 19, 1986.

"Overview of Asbestos Analytical Methods" presented at the Connecticut River Valley Section of American Industrial Hygiene Association, Hartford, CT, March 4, 1987.

"Air Sample Analysis II: Electron Microscopy", Asbestos Abatement Air Monitoring Course, Georgia Institute of Technology, Atlanta, GA, March 25, 1987.

"Analytical Tools for Identification of Asbestos Materials in Buildings", Co-authored with Richard L. Hatfield, presented at the American Society of Civil Engineers National Spring Convention, Atlantic City, NJ, April 27, 1987.

"Analyzing Asbestos Brake Dust", Asbestos Brake Maintenance Conference, Georgia Institute of Technology, Atlanta, GA, August 5, 1987.

"Overview of AHERA Requirements", Advanced TEM Asbestos Analysis Course, Georgia Institute of Technology, Atlanta, GA, February 15, 1988.

"Counting and Sizing Procedures", Advanced TEM Asbestos Analysis Course, Georgia Institute of Technology, Atlanta, GA, February 15, 1988.

"Microscopy and AHERA", Northeastern Society of Electron Microscopy, JEOL, Inc., Peabody, MA, February 17, 1988.

"Microscopy and the Asbestos Hazard Emergency Response Act", Inter/Micro, McCrone Research Institute, Chicago, IL, June 28, 1988.

"Asbestos Fiber Counting Rules", ASTM Johnson Conference, Johnson, VT, July 12, 1988.

"Transmission Electron Microscopy Asbestos Analysis Course", Georgia Institute of Technology, Atlanta, GA, June 6-17, 1988.

"Polarized Light Microscopy Analysis of Tremolite/Actinolite in Vermiculite", National Asbestos Council Technical Conference, Boston, MA, September 21, 1988.

"Some Comments on Settled Dust Sample Analysis by Transmission Electron Microscopy", National Asbestos Council Technical Conference, Boston, MA, September 22, 1988.

"Practical Considerations in Designing a TEM Asbestos Laboratory", JEOL, Peabody, MA, September 23, 1988.

TUTORIAL: "Analysis of Asbestos in Water and Other Liquids", Scanning Microscopy International, Salt Lake City, Utah, May 1, 1989.

TUTORIAL: "Analysis of Asbestos in Air", Scanning Microscopy International, Salt Lake City, Utah, May 1, 1989.

"TEM Asbestos Accreditation Seminar", Georgia Institute of Technology, Atlanta, GA, August 1-2, 1989.

"Asbestos in Drinking Water", Water Quality Technical Conference, American Water Works Association, Philadelphia, PA, November 14, 1989.

Professional Development Seminar on TEM X-Ray analysis, NAC Conference, San Antonio, TX, February 18, 1990.

"Current Aspects of Surface Dust Collection and Analysis", NAC Conference, San Antonio, TX, February 19, 1990.

"Recent Research on Fiber Release and Re-Entrainment of Asbestos Dust", NAC Conference, San Antonio, TX, February 29, 1990.

"The Dust Dilemma", NAC Conference, Phoenix, AZ, September 11, 1990.

"How Clean is Clean, The Laboratory Analyst's Point of View of Abatement Clearance", NAC Conference, Phoenix, AZ, September 11, 1990.

"Sizes of Asbestos Fibers in Buildings", NAC Conference, New Orleans, LA, February 21, 1991.

"Analytical Techniques for the Analysis of Lead in Buildings", The Envir. Inst., Marietta, GA, April 22, 1991.

"Asbestos Exposure During and Following Cable Installation in the Vicinity of Fireproofing", co-authored with W. M. Ewing, E. M. Clay, W. H. Spain, T. A. Dawson, J. Chesson, R. L. Hatfield, S. M. Hays, D. L. Keyes and W. E. Longo. Amer. Indust. Hygiene Conf., Salt Lake City, UT, May 22, 1991.

"Settled Dust Collection Methods" and "Interpretation of Results", as Co-director of the Course, Settled Dust Sampling: Asbestos and Other Particulates, Georgia Institute of Technology, Atlanta, GA, August 12, 1991.

"Can You Identify This Material?", Inter-Micro, Chicago, IL, August 22, 1991. Co-authored with E.J. Chatfield and R.J. Lee.

"Overview of Techniques for Detecting Asbestos Fibers in Indoor Air and Settled Dust", American Public Health Association (APHA) Conference, Atlanta, GA, November 13, 1991.

"Analysis of Low-Level Asbestos-Containing Bulk Building Materials by Polarized Light Microscopy and Transmission Electron Microscopy", Professional Development Seminar coordinated by J.A. Krewer, Environmental Management '92, April 6, 1992, Pittsburgh, PA.

"Removal of Asbestos-Containing Roofing: Effects of Work Practices on Airborne Asbestos Levels", M.D. Cameron, D.L. Keyes, J.R. Millette, Environmental Management '92, April 7, 1992, Pittsburgh, PA.

"Use of Observational Data and Experimental Studies in Developing Better Asbestos Operations and Maintenance Plans", S.M. Hays, J.R. Millette, Environmental Management '92, April 8, 1992, Pittsburgh, PA.

An Overview of Monitoring Techniques for Asbestos in Settled Dust, ASTM Johnson Conference, July 15, 1992, Johnson, VT.

“Asbestos in Settled Dust”, A Professional Development Course, EM '94, Envir. Inform. Assoc. Conf., March 13, 1994, San Diego, CA.

"Lead Source Determination and Research Activities". J.R. Millette, R.S. Brown, J.P. Bradley, EM '94, Envir. Inform. Assoc. Conf., March 15, 1994, San Diego, CA.

"Dust Sampling and Analysis", ASTM Standards for Asbestos Control, October 27-28, 1994, Atlanta, GA.

"Contamination from Asbestos Dust", Professional Development Seminar, The Environmental Information Association, November 17, 1994, Las Vegas, Nevada.

ASTM Standards for Asbestos Control, American Society for Testing and Materials Course, Nov. 9-10, 1995, Atlanta, Georgia.

"Asbestos Dust Contamination", Seminars, California Environmental Information Association, Nov. 16-17, 1995, Oakland and Long Beach, California.

"Microscopical Examination of Indoor Dusts", Microscopy & Microanalysis '98, Microscopy Society of America, July 15, 1998.

"Use of Electron Microscopy in the Study of Indoor Air Quality (IAQ) Samples", INTER/MICRO-98, Chicago, IL, August 13, 1998.

"Environmental Forensic Microscopy", with R. S. Brown, American Academy of Forensic Sciences, Chicago, IL Feb 20, 2003.

F. Professional Societies

American Industrial Hygiene Association, Georgia Section
Air and Waste Management Association
Society of Sigma Xi
American Chemical Society
American Society for Testing and Materials
Environmental Information Association
American Academy of Forensic Scientists

G. Participation in Scientific Conferences, Technical Committees

"Sampling and Analysis of Asbestos in Settled Dusts" Workshop - USEPA, Risk Reduction Engineering Laboratory, Cincinnati, Ohio, July 11-14, 1989.

Chairman of the Cincinnati EPA Environmental Research Center Electron Microscope Facility Committee.

Member of the Sampling and Analytical Committee, National Asbestos Council.

Member of the American Society for Testing and Materials (ASTM) D22.07, Sampling and Analysis of Atmospheres:Asbestos.

Member of the American Water Works Association Water Quality Division Ad Hoc Committee on Asbestos in Drinking Water and the Technical and Professional Council Committee on Particles in Water and Health Implications.

Served as technical reviewer of papers submitted to a number of journals, including Scanning Electron Microscopy, Science, American Water Works Association, American Industrial Hygiene Association, NAC Journal.

Member of the USEPA Asbestos Methodology Subcommittee.

Member of Ambient Water Quality Criteria Document Review Panel for Asbestos, 1980.

Co-chairman for the October 2, 1982 and June 2, 1984 meetings of the Electron Microscopy Society of the Ohio River Valley held at Miami University and USEPA.

Chairman and Organizer--Workshop on Ingested Asbestos--USEPA, Cincinnati, Ohio, October 13-14, 1982. Editor for Proceedings Published in Vol. 53 of Environmental Health Perspectives, 1983.

Member ASTM Committee D-22 on Sampling and Analysis of Atmospheres.

Chairman, American Water Works Association Standard Methods Joint Task Group #200Z on Asbestos in Water.

Chairman, Asbestos Session, Inter/Micro - 88, Chicago, IL, June, 1988.

Member EPA Asbestos Hazard Emergency Response Act (AHERA) Technical Panel developing TEM clearance procedure.

H. Consultant Activities

Testified as an expert witness in the Connecticut State Capitol at a hearing of the State of Connecticut Department of Health Services concerning the development of regulations governing the use of asbestos-cement pipe, September 16, 1980.

Technical input into the USEPA Asbestos Methodology subcommittee as part of a team effort which resulted in the development of the USEPA Interim Procedure for Fibrous Asbestos, Transmission Electron Microscopy Method, the first step toward a standard USEPA method for analyzing asbestos in water.

Technical assistance to the USEPA regions in the form of asbestos analyses has helped determine the extent of potential asbestos exposure to populations through their drinking water.

Interviewed by "Maclean's" Canada's Weekly News magazine, July 21, 1986: "Health: A Battle to Rehabilitate Asbestos" pp. 39-41.

Member Technical Working Group on Asbestos in Public and Commercial Buildings for the U.S. EPA Policy Dialogue Group, Washington, D.C., September 12, 1989.

Instructor for the Electron Microscopy Course on Asbestos given at the JEOL Training Center, Peabody, MA, August 17-21, 1987, May 2-6, 1988, July, 1989.

Instructor for Georgia Tech "Asbestos Analysis by Electron Microscopy" course, 1987-1988.

Instructor for TEM Asbestos Analysis Course, McCrone Research Institute, 1988-1989, 1999.

Instructor for TEM Asbestos Analysis Course, MVA Scientific Consultants, 1999 – Present.

Panel Member on the U.S. Environmental Protection Agency Workshop on Vermiculite Attic Insulation, February 17-18, 2004, Alexandria, VA.

I. Other Information

Completed Contracts, Grants, and Interagency Agreements Course for EPA Project Officers given in cooperation with the Ohio State University, 1976, and a similar course given in 1983.

Completed Course on Introduction to Supervision, U.S. Civil Service, 1979; Analytical Electron Microscopy, JEOL, Boston, 1979; Selection of Tests for Assessment of Hepatotoxicity, SOT, Atlanta, 1984. Sampling and Evaluating Airborne Asbestos Dust, NIOSH, Cincinnati, 1977.

EXHIBIT 2

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Microscopical Studies of the Asbestos Fiber Releasability of Dryer Felt Textiles

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KEYWORDS

Asbestos, dryer felts, textiles, PLM, polarized light microscopy, PCM, SEM, TEM, paper making, glove box, chamber testing

ABSTRACT

Dryer felts are commercial woven textile materials used in the paper making industry to aid in the removal of moisture from the wet paper product. Some dryer felts used in the paper making industry contained asbestos. Microscopical tests including polarized light microscopy, scanning electron microscopy, phase contrast microscopy, and transmission electron microscopy were used in the testing that determined that particles including asbestos fibers are released from the dryer felts during use.

INTRODUCTION

Since the development of paper making machines, dryer felt textiles have been used to separate the water from the wet paper material to form dry sheets or rolls of paper. On a paper machine, the main purpose of the dryer felt is to improve the heat transfer from the hot dryer to the paper (1). The dryer felt must have strength to hold the paper tightly against the heat drum, absorbency to pick up and hold water, and porosity to permit the passage of water vapor. Dryer felts are commercial textile materials. Wool fibers were used initially in the dryer felts of the 1800s. Later, woven cotton fabrics were used. To overcome the problems caused by decomposition and attack by heat, a number of different types of fibrous materials were tried in the construction of dryer felt fabrics. Felts with fibers of hemp, linen, Monel wire, dacron, nylon, polyester, polypropylene and acrylic were all tested over the years. In the 1920s asbestos fibers were introduced and found to provide good wear resistance and provide longer performance life than cotton felts (2). The initial asbestos dryer felt had an asbestos face and a backing of hard twisted, loosely woven cotton yarn. The cotton cloth was to take the pull, but be protected by the insulating asbestos layer from the heat of the drying cylinder. The felt had to be able to withstand a continuous cycle of wet and dry conditions. The function of this felt has been described as follows (2): "It (the asbestos material) absorbs water very easily and gives it up again very readily, therefore it dries very quickly. The dryer felts become moist, as it is well known, and must be dried again on the felt dryer." At the beginning portion of the dryer sequence where the paper pulp is first dried, the moisture in the dryer felt is high, over 50% moisture content. As it progresses down the machine, the paper and therefore the felt textile become drier. At the end, the paper and the felt are hot and dry with a moisture content of approximately 5%.

When there was a break in the paper product on a paper machine, workers would blow off the residual paper material from the dryer felt with compressed air with pressures from 60 to 90 psi. A test was performed to gather information about the potential for asbestos fiber release into the air from the felts during this compressed air blowing.

MICROSCOPICAL METHODS

"A microscope finds many uses in a paper mill" (1) however, there is no standard method for the analysis of dryer felt textiles. To determine the composition of a dryer felt, it is possible to use a modification of the light microscope method used in the determination of the fiber composition of paper, TAPPI (Technical Association of the Pulp and Paper Industry) Method T401 (3). In the paper fiber analysis, the paper is first defibered and then stained on a microscope slide. A number of stains are used to identify various fibers. Common stains include Graff's "C" stain and Herzberg stain. The latter stains rag (cotton) fibers red, bleached wood fibers blue, and ground wood yel-

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low. The "C" stains have a much broader range of colors, so many types of fibers can be identified. Other stains include Selleger's, Alexander's, Kantrowitz-Simmon's, Lofton-Merritt, Wilson's and Bright's. None of these stains affect asbestos fibers and procedures such as polarized light microscopy (PLM) and dispersion staining commonly used with bulk asbestos building samples (4) are employed for identification of the asbestos fibers. A cross-hair eyepiece is used to determine the number of fibers of each type that are present. At least 300 to 500 fibers are usually counted. Weight factors given in Method T401 for each of the types of fibers found in the paper are used to calculate the full composition of the paper sample. For asbestos dryer felt samples, a weight factor for asbestos must be determined for the final calculation.

Air samples are analyzed for asbestos using both light and electron microscope techniques. The standard procedure for the analysis of air samples for asbestos in an occupational environment is the National Institute of Occupational Safety and Health (NIOSH) Method 7400 (5). This procedure requires the use of a phase contrast microscope (PCM) to count fibers greater than 5μm in length with at least a 3 to 1 aspect ratio. The method counts all fibers seen at 400 times magnification without distinguishing asbestos fibers from other fibers. It counts only fibers greater than approximately 0.25μm in diameter, the optical resolution limit of the phase contrast microscope. The NIOSH Method 7402 is a transmission electron microscope method that can be used to distinguish the asbestos fibers from the non-asbestos fibers counted by PCM. The NIOSH 7402 method provides a percentage determination of asbestos fibers greater than 5μm long and 0.25μm in diameter among all fibers of the same dimensions (6). This percentage can be applied to the NIOSH 7400 PCM count to get information about the concentration of asbestos fibers in the air when there is a mixture of fiber types present.

The International Standards Organization (ISO) Standard Method 10312 is a transmission electron microscope method used to provide very detailed information about asbestos fiber concentrations in air (5). Although it is most often used to measure all asbestos fibers greater than 0.5μm in length and without limitation as to diameter, it can be used to gather detailed information about the asbestos fibers in the range that would be counted by PCM, namely: asbestos fibers greater than 5μm long and 0.25μm in diameter. With an ISO 10312 analysis, not only is there information about the asbestos bundles and fibers that make up a PCM count, but there is also information about how the asbestos structures that contain the fibers are found arranged on the air filter.

The Asbestos Hazard Emergency Response Act (AHERA) Method uses the transmission electron microscope to measure asbestos in air (6). This method was developed for the evaluation of the air in the final clearance of school buildings, but is used for many ambient asbestos air sampling projects. Airborne structures are counted that contain at least one asbestos fiber greater than 0.5 μm in length, without limitation as to diameter. The method can be used to gather information about the full asbestos fiber exposure because nearly all asbestos fibers are identified and counted. However, the method was developed as a rapid counting procedure and may be biased toward lower counts because it considers one single asbestos fibril or a cluster of asbestos fibrils the same in the final count. (Each fibril or cluster is counted as one asbestos structure.)

Scanning electron microscope (SEM) techniques were also used to examine asbestos on adhesive lift Post-it Note samplers (7). Portions of the notes were cut and placed on a stub. They were lightly coated with carbon or gold to provide a conductive surface for electron microscopy. The samples were scanned first at magnifications of 100 - 300 times for fibrous particles. If no fibers were seen, additional scans were performed at a magnification of 1000 times. Energy dispersive x-ray analysis was used to differentiate the asbestos fibers from other fibers.

PARTICLE RELEASE TESTING

The testing for particle release from asbestos-containing products is usually done in several phases. The first phase involves a PLM determination that the product does indeed contain asbestos and a close examination of the product to determine whether or not asbestos fibers are seen on the surface of the material. If a product totally encapsulates the asbestos fibers in a binder so that no fibers are visible on the surface, it is unlikely to release fibers during light abrasive activities. The second phase involves testing for release of particles (including asbestos fibers) by hand (onto a finger) or onto a light adhesive material. Post-it Notes provide a reproducible adhesive lift that will not damage the surface of most products. Particles released onto a finger can be transferred to carbon tape and prepared for SEM examination. The Post-it Notes can be prepared directly. The third phase of testing (glove box testing), involves collecting airborne particles in an enclosed glove box chamber under controlled conditions while some activity is

performed on the product. The air sample filters are analyzed by PCM and by TEM. The fourth phase of testing involves a full simulation of an activity in an enclosure large enough for a worker (with protective clothing and respirator) to perform that activity.

In the laboratory, studies of the first three phases of testing were undertaken to determine the releasability of particles including asbestos from the dryer felt textile. No full scale simulation was done. The available dryer felt pieces were small in comparison to the felt textiles used on dryer machines. Individual dryer felts were quite large, often over 200 inches wide and 100 ft long. Several felts could be used on one drying machine.

The studies included the close examination of a number of dryer felts of different styles and types by eye and with the aid of different types of microscopy. Some felts were tested for asbestos identification by polarized light microscopy (PLM). Simple fiber release tests were performed with light adhesive papers (Post-it Notes) and with a wet finger. The particles released onto a finger were transferred to adhesive material and then they and the Post-it Notes were examined by scanning electron microscopy (SEM). A test of airborne fiber release was performed in a closed glove box chamber with air samples collected on membrane filters. The design of the glove box chamber was based on asbestos fiber release testing chamber protocols developed by the Consumer Product Safety Commission (CPSC) and the United States Environmental Protection Agency (USEPA) (8, 9). The testing was done in a NuAire 701 sealed glove box (365 liter volume) with a mixing fan. The glove box had HEPA filters on both the air inlet and outlet. The testing involved two separate tests where an air hose with 60 psi compressed air was directed at each of the two pieces of dryer felt textile material for 5 minutes. The released particles were collected with standard air filter cassettes (0.8 um MCE filters) at 2 and 2.2 liters per minute flow rates. The air filters were prepared using direct procedures and analyzed by phase contrast light microscopy (PCM) and three different transmission electron microscopy (TEM) techniques.

EQUIPMENT

Close examination was done by stereomicroscopy utilizing a Zeiss Stemi 2000 stereomicroscope having a magnification range from 6.5X to 47X. Asbestos analysis was done by polarized light microscopy including microchemical tests utilizing an Olympus BH-2 polarized light microscope having a magnification range from 40X to 1000X. Finger dust releases and Post-it Notes were examined and analyzed by scanning electron microscopy (SEM) using a JEOL 6400 coupled with an x-ray energy dispersive spectrometry (EDS) Noran Voyager system. The air samples were analyzed by PCM with a Nikon Alphaphot-2 light microscope and by TEM with an analytical electron microscope (AEM), a JEOL 1200 EX, equipped with a Noran EDS x-ray analysis system.

MATERIALS

Asbestos-containing dryer felts have not been sold commercially since the 1970s. Therefore it was not possible to purchase dryer felt textile pieces for testing. Retired paper mill workers provided 20 pieces of dryer felt textiles that had been associated with a paper mill. Upon testing for asbestos content, two of the 20 were found to contain asbestos. These sample felts were identified as SA-0001 and SA-0005. The manufacturers of the felts were not known. Sample SA-0001 was representative of a tightly woven textile material. Sample SA-0005 was representative of a loosely woven textile. Several hundred additional textile samples were provided from sets of stored samples collected by two manufacturers of dryer felt textiles over a number of years. The samples had been collected at various paper mills and sent to be analyzed in the laboratories of the manufacturers apparently to gain information about competitors' products. The manufacturer's sample packets contained information about the original manufacturer of the felts and most contained analysis sheets from the modified TAPPI T401 microscope method which showed the percentages of various fiber types.

Dryer felt textiles from six manufacturers (A - F) were studied. Early felt styles (1950s) as well as later styles were included in the study. Earlier dryer felt textiles usually contained cotton and asbestos; later felts utilized various synthetic fibers with the asbestos. One felt, comprised totally of synthetic fibers, was included in the study as a control.

SAMPLE DESCRIPTIONS

Sample CS00103A was a felt from manufacturer F with 39% asbestos. The asbestos fibers were in only one of the fabric directions. The fabric analysis report indicated that the fabric was not resin impregnated. However, the report indicated that the filling (with asbestos) was resin treated prior to weaving. The sample was from a dryer felt that had run approximately 9 months.

Sample CS00118A was a felt from manufacturer F with 64% asbestos. The asbestos fibers were in both fabric directions. The fabric analysis report indicated that the fabric did not appear to be resin impregnated. However, there was clear evidence of a coating on some of the fibers. The sample appeared to be unused.

Sample CS00162A was a felt from manufacturer F with 56% asbestos. The asbestos fibers were used in both directions of the weave. There was no evidence of a resin coating on this felt. The sample appeared to be from an unused felt.

Sample CS00418A was a felt from manufacturer F with 58% asbestos. The asbestos fibers were used in both directions of the weave. The felt was resin treated during finishing which imparted a blue color to the fabric. This sample appears to have been used to some extent.

Sample CS03033A was a felt from manufacturer A with 44% asbestos. The asbestos fibers were used in one of the directions of the weave. The felt was resin treated during finishing. The Sample was in used condition.

Sample CS05506A was a felt from the 1970s that had no asbestos in it. It was from manufacturer D with only synthetic fibers in its composition. The sample appeared to be in unused condition.

Sample CS05600C was a felt from manufacturer D with 41% asbestos. The asbestos fibers were used in one of the directions of the weave. The felt was resin treated during finishing which imparted a purple color to the fabric. The sample appeared to be in unused condition.

Sample CS05628A was a felt from manufacturer D with 53% asbestos. The asbestos fibers were used in one direction of the fabric. Information about this type of felt suggested that it was treated with an acrylic resin during finishing. The felt appeared to be unused.

Sample SCWX014609B was a felt from manufacturer E made in the 1950s that had 16% asbestos. The asbestos fibers were in only one direction of the weave. The piece of felt appeared to be unused. It did not have a coating.

Sample SCWX015562A was a felt from manufacturer C made in the 1950's with asbestos in one of the fabric directions. A colorless resin was found to partially coat some of the fibers. The sample appeared to be unused.

Sample SCWX015565A was a felt from manufacturer C with 80% asbestos. The asbestos fibers were used in one fabric direction. The resinous coating was only in the fabric weave direction containing asbestos. The sample appeared to be unused.

Sample SCWX015591A was a felt from manufacturer C with 75% asbestos. The asbestos fibers were used in both fabric directions. A resinous coating was indicated. The sample was from a dryer felt that had run for 168 days.

Sample SCWX015620A was a felt from manufacturer C made in the 1950s with 23% asbestos. The asbestos fibers were used in both fabric directions. No coating was indicated. This sample appeared to be a sample of a new felt.

Sample SCWX015881A was a felt from manufacturer B with 56% asbestos. The asbestos fibers were used in both fabric directions. This sample came from a felt that had run for 132 days.

Sample SCWX015886A was a felt from manufacturer B with 74% asbestos. The asbestos fibers were used in both fabric directions. This sample came from a felt that had run for 51 days.

Sample SCWX015890B was a felt from manufacturer B with 77% asbestos. The asbestos fibers were used in both fabric directions.

Sample SCWX015903A was a felt from manufacturer B with 33% asbestos. The asbestos fibers were used in both fabric directions. This sample was in used condition.

Sample SCWX015964A was a felt from manufacturer B with 22% asbestos. The asbestos fibers were used in one of the fabric directions. This sample was in unused condition.

Sample SCWX016076B was a felt from manufacturer E with 20% asbestos. The asbestos fibers were used in both of the fabric directions. A polyacrylate coating on the asbestos fibers was indicated. This sample may have had some use but appeared to be in good condition.

Sample SCWX016082B was a felt from manufacturer E with asbestos fibers in both of the fabric directions. The sample condition was listed as "new".

Sample SCWX016126A was a felt from manufacturer B made in the 1950s with asbestos fibers used in both directions of the weave. Information suggested that there may have been a coating of latex initially, however, this used felt showed no indication of any coating. This sample was in used condition.

Sample SCWX016197A was a felt from manufacturer A with 41% asbestos. The asbestos fibers were in one direction of the fabric weave. It showed evidence of a resinous coating on some of the fibers. This sample came from a dryer felt that had been used for 262 days.

Sample SCWX016281B was a felt from manufacturer E with 44% asbestos. The asbestos fibers were in

Table 1. Summary of Felt Textile Asbestos Analyses and Adhesive Release Testing

Sample #	PLM Analysis	SEM of Post-it	SEM of finger dust
CS00103A	Chrysotile	Asbestos Detected	Not Done
CS00118A	Chrysotile	Asbestos Detected	Asbestos Detected
CS00162A	Chrysotile	Asbestos Detected	Not Done
CS00418A	Chrysotile	Asbestos Detected	Not Done
CS03033A	Chrysotile	Asbestos Detected	Not Done
CS05506A all synthetic	No asbestos detected	No asbestos detected	No asbestos detected
CS05600C	Chrysotile	Asbestos Detected	Not Done
CS05628A	Chrysotile	Asbestos Detected	Asbestos Detected
SCWX014609B	Chrysotile	Asbestos Detected	Not Done
SCWX015562A	Chrysotile	Asbestos Detected	Asbestos Detected
SCWX015565A	Chrysotile	Asbestos Detected	Not Done
SCWX015591A	Chrysotile	Asbestos Detected	Not Done
SCXX 015620A	Chrysotile	Asbestos Detected	Not Done
SCWX015881A	Chrysotile	Asbestos Detected	Not Done
SCWX015886A	Chrysotile	Asbestos Detected	Not Done
SCWX015890B	Chrysotile	Asbestos Detected	Not Done
SCWX015903A	Chrysotile	Asbestos Detected	Not Done
SCWX015964A	Chrysotile	Asbestos Detected	Not Done
SCWX016076B	Chrysotile	Asbestos Detected	Asbestos Detected
SCWX016082B	Chrysotile	Asbestos Detected	Not Done
SCWX016126A	Chrysotile	Asbestos Detected	Asbestos Detected
SCWX016197A	Chrysotile	Asbestos Detected	Asbestos Detected
SCWX016281B	Chrysotile	Asbestos Detected	Not Done
SCWX016298A	Chrysotile	Asbestos Detected	Not Done
Sears #2	Chrysotile	Asbestos Detected	Not Done
Sears #3	Chrysotile	Asbestos Detected	Not Done

one of the fabric directions. The analysis report indicated a polyacrylate resin on the asbestos portion of the fabric. This used sample had run 126 days.

Sample SCWX016298A was a felt from manufacturer E with asbestos fibers in both of the fabric directions. This sample appeared to be in unused condition.

Sample SCWX016308A was a felt from manufacturer E with asbestos fibers in one of the fabric directions. This sample appeared to be in unused condition.

The sample labeled: "Sears #2" was a felt from manufacturer F with asbestos fibers in both of the fabric directions. Sample Sears #2 appeared to be used.

The sample labeled: "Sears #3" was a felt from manufacturer F with asbestos fibers in one of the fabric directions. Sample Sears #3 appeared to be unused.

RESULTS OF EXAMINATION, PLM ANALYSES AND ADHESIVE RELEASE

Examination and PLM analysis of Sample SA-0001 showed it to be a white, relatively tightly woven material containing approximately 20% chrysotile asbestos, 45% cotton, 20% polyester, and 15% rayon. Sample SA-0005 was found to be a brown. loosely woven material containing approximately 25% chrysotile asbestos, 15% fiberglass, 18% polyester, 16% Aramid, 25% acrylic and 1% nylon. There was no evidence of a resin coating on the felt fibers of either of the felts. When the felts were handled in both wet and dry conditions, there was microscopical evidence that particles of chrysotile asbestos were released from both the felts onto fingers.

As shown in Table 1, all the manufacturers' felt textile samples that contained asbestos released fibers

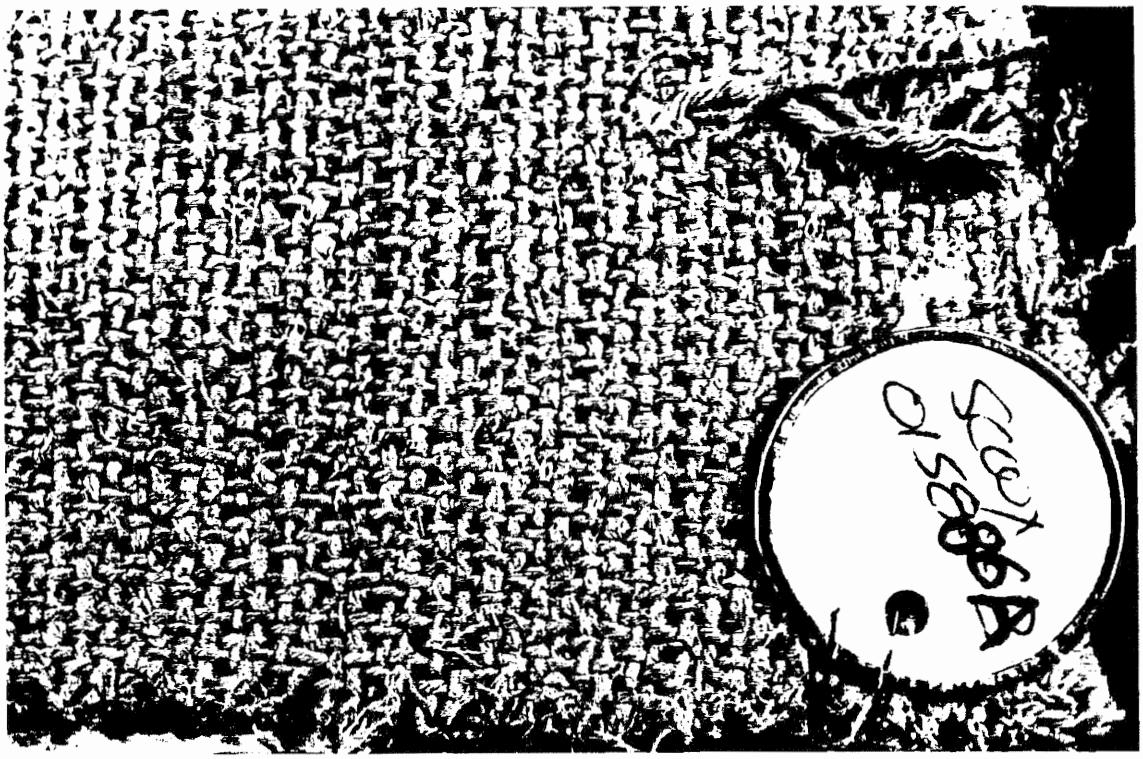

Figure 1. Asbestos Containing dryer felt textile, Sample 015886A as received.

Figure 2. Scanning electron microscope image of chrysotile asbestos fibers released from the felt shown in Figure 1 onto a Post-it Note light adhesive sampler.

when subjected to the light adhesive lift test or when touched with a finger. Figures 1 and 2 show an example of a piece of felt textile and a scanning electron microscope image of the asbestos fibers released onto a Post-it Note adhesive test from that felt. The resin coatings associated with a number of the samples did not prevent asbestos fiber release.

RESULTS OF CHAMBER TESTING

The results of air sample analyses are shown in Table 2. Only samples SA-0001 and SA-0005 were tested in the chamber. By phase contrast microscopy (NIOSH 7400), the fiber concentration in the chamber during compressed air blowing of the felt for both the tightly woven and loosely woven asbestos felts was over 30 fibers per cc. The TEM analyses by NIOSH 7402 showed that 96-97% of the fibers were chrysotile asbestos. The TEM ISO count also showed that there were concentrations over 30 fibers per cc of asbestos fibers larger than 5μm. The TEM analysis by the AHERA methods showed that there were approximately 10 times as many asbestos fibers of all sizes in the chamber as were counted by the phase contrast method. An example of one of the asbestos structures seen on the air filters is shown in Figure 3. This structure would be counted as a 'fiber' under the light microscope NIOSH 7400 counting rules, but because of the greater resolution of the TEM, was counted as a 'bundle' under the ISO and AHERA counting rules.

Table 2. Results of Air Sample Analyses from Chamber Tests of Compressed Air on Asbestos Containing Dryer Felt Textiles

Sample Number	Description	NIOSH 7400 PCM F/cc	NIOSH 7402 % Asbestos	AHERA TEM Asbestos str/cc	ISO TEM >5 μm F/cc
3	Background	0.05	0%	0.08	0 (0.08)
4	Background	<0.04[1]	0%	0 (0.07)[3]	0 (0.07)
5	Blowing Felt 1	75[2]	96%	OL[4]	OL
6	Blowing Felt 1	48[2]	97%	OL	OL
7	Background	<0.05	0%	0 (0.08)	0 (0.08)
8	Background	<0.04	0%	0 (0.07)	0 (0.07)
9	Blowing Felt 5	35	96%	360	140
10	Blowing Felt 5	41	96%	550	162
13	Room Air	<0.002	0%	0.004	0 (0.004)
14	Blank[5]	(2/100)	0%	0/10	0/10

1. The blank value (2 fibers/100 fields counted) was subtracted in calculating fiber loading densities. Reported values are based on the limit of detection (LOD) of 7 fibers/mm2 for the NIOSH method. Fiber loading densities below this threshold value and the resulting airborne fiber concentrations are reported as less than (<) the calculated LOD value.
2. Extreme loading with fibers and much overlap of fiber bundles evident. Values may not be accurate but are certainly higher than samples 9 and 10.
3. When no asbestos fibers were found, the analytical sensitivity is given in parenthesis.
4. OL = Overloaded, too high to count all sized fibers accurately.
5. No air volume was collected for the blank. Values are given in terms of number of fibers or structures per number of areas analyzed.

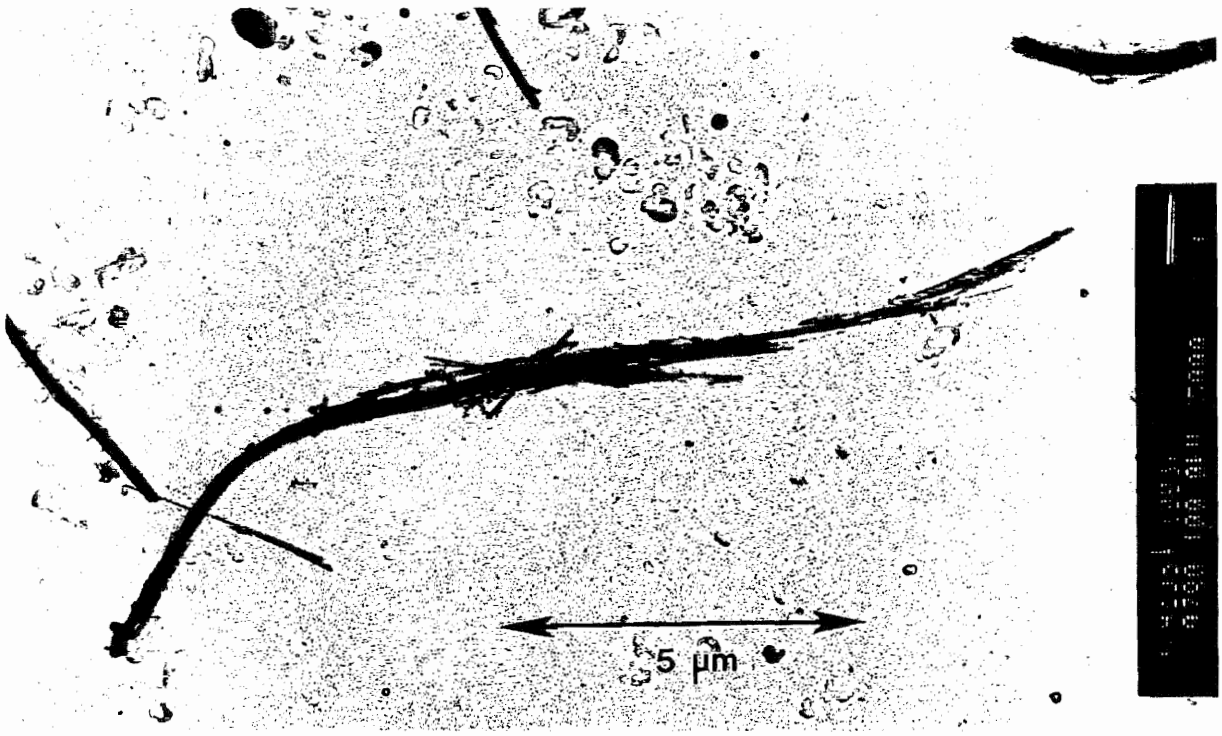

Figure 3. Transmission electron microscope image of a chrysotile asbestos structure in an air sample collected during the compressed air blowing of an asbestos dryer felt textile (Sample SA-0005). Under the NIOSH 7400 method this structure would be counted as a fiber. Under the AHERA and ISO counting rules this structure would be counted as a bundle.

CONCLUSIONS

Dryer felts of early and later styles and in used and unused conditions all released asbestos fibers when touched by hand or subjected to the test of a light adhesive pull of a Post-it note. Resin coatings on the fabric or fibers did not prevent asbestos fibers from being released. For the felt samples tested, when handled in a dry condition, particles of chrysotile asbestos were released from the felt and adhered to fingers. When handled in a wet condition, chrysotile asbestos also adhered to fingers. When the wet residue dried the released asbestos fibers could be seen with the SEM.

No asbestos fibers were found in the testing of the synthetic dryer felt which contained no asbestos.

Chamber testing showed that particles are released from the dryer felt textiles of tight weave and loose weave when it they are blown with 60 psi compressed air. TEM showed that the majority (approximately 96%) of the fibrous particles longer than 5μm released from the felts during blowing with compressed air were chrysotile asbestos fibers. The airborne concentration of asbestos fibers in the chamber during the blowing of dryer felts with compressed air was over 30 fibers per cc.

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